The SCIENCE COUNSELOR

A Quarterly Journal for Teachers of Science in the Catholic High Schools

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The Science Counselor

A QUARTERLY JOURNAL *of teaching methods and scientific information for teachers of science in the Catholic high schools. Published at Duquesne University, Pittsburgh, Pennsylvania, in March, June, September and December by*

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Catholic Action . . .

When a journal nears its second birthday, it should be strong enough, financially, to stand alone. We regret to report that THE SCIENCE COUNSELOR is not yet able to do so. Perhaps everyone is not doing his share in helping it to succeed. Are *you?*

Duquesne University founded this journal in a praiseworthy effort to assist teachers of science in the Catholic high schools of the United States. It hoped to make them better and more successful teachers by bringing to them authoritative information concerning recent developments in science, and by discussing with them new and practical and effective teaching methods. Whether or not some measure of success has been achieved is for you to decide.

The very considerable financial assistance that this journal receives from the University cannot be continued indefinitely. To replace it we must have more subscribers, more advertisers. There is no desire to profit, but expenses must be met. Here is an opportunity for Catholic Action. Already we have subscribers in forty states and several foreign countries. Are you numbered among them? If you feel that the work that THE SCIENCE COUNSELOR is doing worth while, if you want to aid the Catholic schools and the Catholic scientific press, if you are interested in having this journal continue to develop and grow, you must help. You should send in your subscription at once, or your renewal if your subscription has expired.

You can be of assistance in another way.

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If even a thousand science teachers in the Catholic high schools of the country should begin to talk to their dealers and publishers about THE SCIENCE COUNSELOR, their response in advertising would be substantial and immediate.

What ACTION will you take?

In Hoc Signo Vinces

● **By Jean Piccard**

The whole world knows of Dr. Piccard's stratosphere adventures. Our readers, however, are the first to learn of this interesting little incident in connection with it.

To say the least, this human interest story reveals the man.

Dr. Piccard is planning another stratosphere flight. He is now connected with the department of aeronautical engineering at the University of Minnesota.

●

Our Stratosphere flight took only seven and three quarters hours, but the preparations were long and eventful. Mr. Henry Ford had allowed us the use of his great airplane hangar. He frequently came to inquire how we got along, and whatever we needed he was willing to let us have. He supplied us not only with space in which to work and with tools, but often with power for light, for electric drills, etc., when we wanted to work at night or on holidays when the power was ordinarily shut off.

The great gas bag had been put in condition by the manufacturer, but there was much work to be done with the gondola. The barometers had to be put in place and connected with the outside. These and many other outlets for wires and tubes had to be made air-tight. The ten little windows with their heavy double glasses were mounted very carefully. If nine windows hold good and one breaks it is, to say the least, unfortunate! The main gas valve, the ballast release, the rip cord, all these are of vital importance for the navigation of a stratosphere balloon.

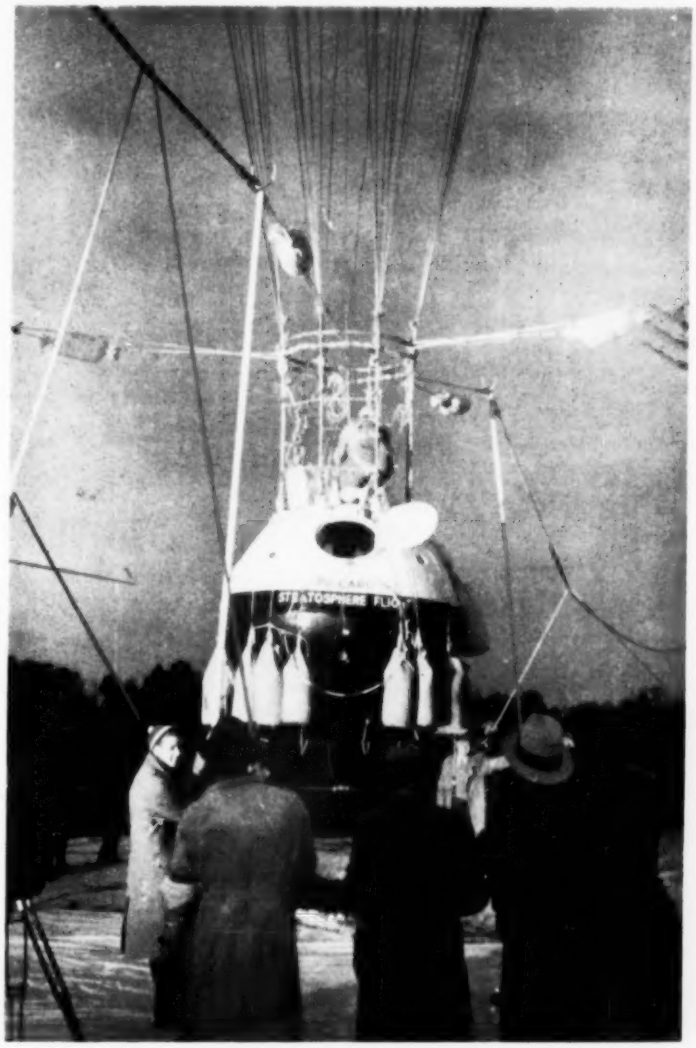
The scientific program centered around the investigation of the mysterious cosmic rays coming from far away empty space. One important question was: What direction do they come from and, since they come from many directions, what is their strength from various directions?

For this part of the study of cosmic rays we were obliged to rotate our instruments around a vertical axis. Unfortunately the instruments were too large to be conveniently rotated within the gondola. We, therefore, decided to rotate the gondola itself. This involved, however, a new and grave problem. The gondola is connected to the balloon by many suspension ropes and by several control ropes.

The only solution was the rotation of balloon, gondola and all. A small, electrically driven propellor had to be suspended as far out as possible in order to increase its moment. In a previous flight we had mounted the engine on a large T-shaped wooden support. The two arms of the T were suspended by strings from the equator of the balloon and the main beam was directed, horizontally, toward the gondola. It was carrying the wires. For our last flight we needed as much lever as possible and we placed the propeller on a fourth arm, a prolongation of the main beam of the T. This gave the whole frame the form of a Latin cross, about eighteen feet long.

While we were making the preparations for our flight in the large hangar of the Ford Airport, many visitors came to see our installation and to see the balloon which was going to go to the stratosphere. There were teachers, literary men, engineers, men of science,

Continued on Page Ninety-two



THE CROSS OF WHICH DR. PICARD SPEAKS MAY BE SEEN AT THE LEFT. MRS. PICARD IS ATOP THE GONDOLA, WAITING FOR THE SIGNAL FROM THE GROUND PILOT FOR THE RIGHT MOMENT TO SEND THE BALLOON INTO THE AIR.

Equipping the Modern Science Room

● By Walter E. Hess
ADVISOR, SECONDARY EDUCATION, PENNSYLVANIA DEPARTMENT OF PUBLIC INSTRUCTION

Here is information of importance to every science teacher and to every person concerned in planning new science rooms or in remodeling old ones.

This article is practical, not theoretical.

Embodying as it does the results of extensive first-hand experience, it will help every teacher who wants his science room to be a real "workshop where youth will be better able to find expression for their interests, and thus live vitally within the school."

The most modern ideas in presenting science education in secondary schools are here discussed.

●

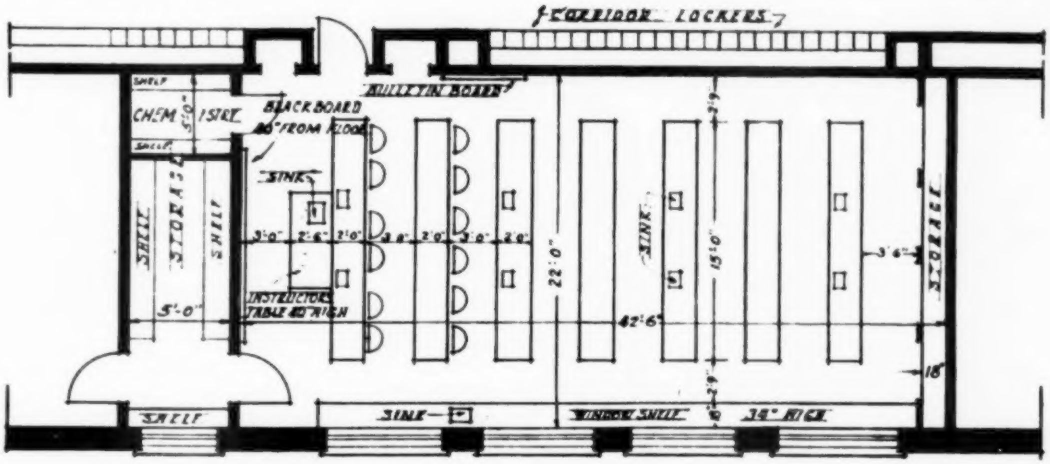
In a paper published in 1749, Benjamin Franklin proposed that pupils were to read natural history and were to practice "a little gardening, planting, grafting, inoculation, etc."; and "now and then excursions made to the neighboring plantations of the best farmers, their methods observed and reasoned upon for the information of youth." From this it will be noted that science teaching very early was recognized as an important phase of the educational program of this State, including both the elementary and the secondary school levels.

In realizing the objectives of secondary education science has much to offer. Since the middle of the nineteenth century it has become an increasingly important part of the school program. It is closely related to the everyday life of the individual. It helps to furnish the basis for rational and scientific living and thinking. A knowledge of the sciences is essential for an intelligent understanding of the local environment and for an appreciation of the many phases of modern life. Today people are called upon to make decisions, to evaluate and to judge products, materials and situations where both scientific facts and procedures are needed. A knowledge of science is one of the most forceful means for combating superstition. Life is made more worth living when scientific attitudes and appreciations aid the individual to interpret the things about him.

With the increased interest in science instruction has come a change in point of view in educational philosophy. Science has too long been taught to pass examinations rather than to form habits of thinking. Too often science teaching has stopped with the learning of facts. Facts are important as foundation work, but teaching should be broader in order to develop methods of thinking. The pupil should learn to think rather than learn to recite, or retell facts. New knowledge of the learning process has given a different meaning to methods of instruction in science. In early school history science instruction seemed to be offered most generally to a selected group of pupils. With the rapid growth in secondary school enrolment and an increased use of science in the everyday life of all individuals, has come a corresponding growth in the number of science classes. This rapid expansion has caused considerable attention to be directed toward the cost of maintaining a most valuable part of the school curriculum. In view of these factors, school administrators have been confronted with the problem of providing science instruction to a larger number of pupils and at the same time of justifying the increased expenditure of money.

Formerly, it was the practice to conduct classes in science on the basis of three single periods and two double periods weekly, the two double periods being utilized for laboratory activities. Such a set-up produced an inflexible time schedule. Difficulties were encountered in the fact that rooms were standing idle and pupils were forced into study groups. A partial solution to this problem has been found through the introduction of the longer period. This period, approximating an hour in length five times per week, obviates the need for double periods. Many teachers feel that the double period causes considerable waste of time. With the single, longer period, held daily, a modification in teaching procedures can be made to such an extent that a variation in type of instruction can be made to meet the needs of the class at a particular time. Laboratory activities need not be confined to any definite day. A committee of the National Society for the Study of Education, reporting in the Thirty-first *Yearbook*, was decidedly in favor of eliminating the double period. They stated that the single longer period was more economical in that it conserved pupil and teacher time, and made the science room available for the use of other classes.

A shift in subject presentation has also been noticeable during the last two decades. The formal abstract manner of presenting materials in science has given way to the problem-solving or activity type of instruction. Science teaching is becoming more child centered and less subject matter centered. Victor H. Noll, Research Director, Institute of School Experimentation, Teachers College, states that "habits of thinking scientifically should be taught directly as such. Experimenters have found that direct definite training in specific situations in the elements of the scientific attitude is more effective by far than extensive teaching of science subject matter." This change in emphasis naturally gives rise to a need for a different type of classroom.



SCALE 1/12"

NOTE -
PROVIDE GAS AND ELECTRICITY FOR EACH TABLE - WATER FOR SINKS WHERE INDICATED

PLAN No. 1
EQUIPMENT LAYOUT
WITH SIX PUPIL TABLES AND WINDOW SHELF
FOR A SCIENCE LABORATORY — CLASS ROOM

DEVELOPED IN COLLABORATION WITH THE DIVISION OF SECONDARY EDUCATION

COMMONWEALTH OF PENNSYLVANIA
DIVISION OF SCHOOL BUILDINGS
Hubert C. Eicher, Director
H - G - C C

M

Basic Principles in Developing the Science Room

In view of these specific needs that have been revealed, the committee of the National Society[5] outlined nine basic principles which should be included in developing a satisfactory science environment in the secondary school:

1. "A science room is a place where the pupil may receive educative experiences which add meanings to, and give better understandings of, those generalizations in science that contribute to enrichment of life.
2. "Science room experiences are justified by, and take their origin from, the science curriculum, course of study, and learning experiences to be expected of pupils.
3. "A piece of equipment or apparatus is to be evaluated in terms of the educative experience or experiences which it makes possible.
4. "A science room is also a place where the experience of problem-solving is possible.
5. "The plan and design of a science room must provide elements of flexibility.
6. "The design of both classrooms and laboratories should provide facilities for effective teacher demonstrations.
7. "Certain science rooms should provide facilities for individual laboratory work.
8. "Science rooms should provide certain facilities for objectification by means other than the use of concrete materials.
9. "The planning of science rooms and their equipment should be a cooperative project, in which the architect, the engineer, the educational supervisor, and the science teacher each play a proper part."

The Need for a Scientific Approach

In developing a classroom which will most adequately meet the needs of science instruction on an activity basis, many problems are encountered. No "ideal" classroom can be set up. Considerable research is needed for the solution of these problems before any near "ideal" type room can be recommended. The committee[5] has listed ten problems wherein research is needed in order to make the plan and equipment of science rooms a science rather than an art:

1. "A study to determine the available 'apparatus experiences' for the teaching and learning of each of the important generalizations in science.
2. "A study to determine which of several available apparatus experiences is most effective in the teaching and learning of given science facts or principles.
3. "An analytical study to determine the specific educative experiences possible with each of one hundred commonly purchased pieces of science teaching equipment.
4. "A study to determine the types of science problems that pupils can solve through the use of science-room facilities and equipment.
5. "A study to determine the relative value of different demonstration techniques.
6. "An analytical study of laboratory arrangements and the functions of laboratory furniture.
7. "An investigation to determine the frequency of change in basic design and equipment of given

science rooms as compared with the frequency of change in the curriculum which those rooms are meant to serve.

8. "A study to determine the available screen experiences for the teaching and learning of the important generalizations in science.
9. "A study to determine which of several available screen experiences is most effective in the teaching and learning of given science facts or principles.
10. "A series of studies based on the questions set forth in Guiding Principle 9."

Economy and Adaptability

The solution of these problems, scientifically derived, would assist much in determining the type, the size, and the furnishing of the science room. A school room should be something more than the four walls. As one expert has said: "It is an expression of educational individuality and educational ideals."[5] Care should be taken so that the science room is planned for those science classes which have the largest enrolment. Too often this room has been planned primarily for advanced specialized sciences such as chemistry, where the enrolment is small. As a result, the room, while somewhat satisfactory for chemistry, has proved inconvenient and most unsatisfactory for other types of science classes. The major point of consideration should be that of the greatest good to the greatest number of pupils.

Since so many high schools have need for only one science room for all the years of science, it is most desirable and economical that this room be of the combination type. In most cases thought should be given to the possibility of its use for non-science classes, such as English and social studies, when not used for science instruction. The author has visited literally hundreds of schools in Pennsylvania where the science room is being used for non-science classes. In many instances, due to the fact that the room was planned primarily for advanced science laboratory work, they are not only poorly adaptable to types of work in other classes, but even to the major portion of the science instruction itself.

With the increased cost in the school budget and the growing interest in science education, attention drifted toward the cost of this phase of the school program. Administrators, recognizing the value of the knowledge of science to the everyday citizen, were anxious to make any sound adjustments which would continue opportunities for education in this field. The question of period lengths and time allotment per week seems to have been satisfactorily settled by the general adoption of a period approximately an hour in length. With the hour period, laboratory work can be held in the logical and psychological order any day of the week.

The utilization of the floor space devoted to science instruction was likewise given careful consideration. In most cases only one teacher was in charge of the science classes. When he was in the lecture room, the laboratory was idle. School surveys on room utilization revealed in many instances that science rooms were crowded. Because of economy, the tendency has been away from separate lecture rooms and laboratory rooms. Separate rooms give the impression that laboratory and theory are two separate courses. Psychologically, we learn in wholes rather than in parts. The two-room set-up conveys the idea that the pupil learns theory in the one and practice in the other, and attempts to connect both. The general tendency today is that of combining these rooms into one room to secure a more flexible instructional program than when used separately. Separate rooms require that definite days be assigned for regular classroom work and for laboratory work. With the combination room, laboratory work becomes integrated with the other teaching procedures. Almost without exception, teachers who have had experience in both types of set-ups, favor the combination room.

The Combination Classroom-Laboratory

The combination classroom-laboratory can be made adaptable to a specific course in science. If the school is large and there is a need for more than one science room, a duplication of the combination room plan will result. Adjustment will be made in the equipment of these rooms. Such adjustments should take into consideration differences in course content and variation in teaching methods, so that there will be a minimum of inconvenience to instruction and a maximum of economy in room utilization. When two science rooms are necessary, a storage room should be placed between. In the larger school requiring more than two rooms, plans should be so developed that these rooms are grouped as a unit.

Placing the Room

The science room should be well lighted and have plenty of space. A south-facing of the room, with translucent shades, is desired by a large number of science teachers. This provides for plant germination, aquaria, and simple experimentation with light beams. Other persons have advocated the placing of the room in such a manner that little sunlight will reach the room after ten o'clock in the morning. Thus, it is possible to get a reasonable amount of sunlight for plant life and not interfere seriously with school work. In addition to the translucent shades, dark shades should be provided so that the room can be utilized for motion pictures and projection lantern work. Some persons recommend that the room be placed so that it is easiest to maintain an equable temperature in the room in order to facilitate germination projects. This may be accomplished by placing the room over the boiler room, on a sheltered side of the building, or by adjusting the thermostatic control of the room.

Combination Classroom Layout

The accompanying sketch, Plan No. 1, (6-a) shows a type room which has quite generally become a part of the plans in the numerous high school building projects that have been developed during the past few years in this State. It is not recommended as an ideal set-up for a particular school but can, with adaptations, be made to meet local school needs. The plan is a result

Continued on Page Eighty-six

Semi-Micro Methods for High School Chemistry

● By Sister M. Lawrence, O.M., M.S., *(Catholic University)*
MOUNT MERCY ACADEMY

and William J. Schiller, Ph.D., *(University of Pittsburgh)*
MOUNT MERCY COLLEGE

An innovation in laboratory instruction in chemistry.

College as well as high school teachers and administrators are observing with much interest the development of a new technique that is economical of time, space, equipment and materials. Much progress has already been made.

The writers of this timely article are pioneers in the field. They generously offer to help others who are interested.

●

"Multum in Parvo"

A laboratory free from fumes, with students seated at their work, with all necessary equipment within easy reach, and in their experiments using drops of solutions or pinches of solids, free from danger, and experimenting with the utmost economy of space, time and materials: these are conditions which are the attainment of the new semi-micro or small-scale methods applied to laboratory work. Practically all the methods of macro or large-scale chemistry are reducible to the semi-micro. Because of its many advantages it should appeal particularly to the high school teacher who often is limited as to laboratory facilities and funds.

Before embarking on a description of this important new technique it will be well to explain the meaning of the title. The term micro-chemistry refers, as the name implies, to the use of the microscope in chemistry. To distinguish the methods under discussion, wherein the microscope is not used, the term "semi-micro" has been used. It deals with experiments involving drops of solutions, pinches of solids and small-scale apparatus. Since most ordinary laboratory procedures can be "cut down" to the semi-micro requirements, it is simply a case of transposing from one to the other.

To give a more concise idea of the equipment and methods needed, a brief description of these is given below.

LABORATORY: Any room with gas, water, and electricity will do.

FURNITURE: Small desks and chairs. It is preferable that there be gas at each desk, but where this is not convenient alcohol lamps may be used. Sinks are not necessary at the desks as a beaker or other receptacle may be used for waste materials which may be disposed of later.

TEST TUBES: Fermentation tubes of 2 cc. capacity are used. Where very small amounts of materials are involved short lengths of ordinary glass tubing sealed at one end may be used.

BURNERS: Special micro burners may be purchased, or ordinary Bunsen burners of the pilot-light type, which may be converted to micro burners by unscrewing the tubes, may be used. If gas is not available, alcohol lamps can be utilized.

VIALS: These are made of glass and are 21 mm. x 20 mm. Solid reagents are kept in these, and they are used instead of 8 oz. wide mouth bottles for collecting gases.

GLASS MICROSCOPE SLIDES: Precipitations, filtrations, decantations and color reactions are carried out on these.

SPOT PLATES: Porcelain plates with slight depressions or concavities, either in black or white porcelain. These are useful for precipitations or color reactions.

DROP REACTION PAPER: A specially prepared paper for precipitations and color reactions. Where permanent precipitates or colors are obtained on these papers they may be labeled and filed by the student.

CENTRIFUGE: Hand centrifuges for rapid separation of precipitates. These are detachable and are fastened to the desk tops. Their use makes funnels and filter papers unnecessary.

CENTRIFUGE TUBES: Pyrex glass tubes of 2 cc. to 3 cc. capacity for the centrifuge.

DROPPING VIALS: Used for liquid reagents and holding approximately 8 cc. They are equipped with screw caps made of bakelite, and can be kept in drilled reagent blocks. These may be purchased from the Kimble Glass Co.

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Courtesy Fisher Scientific Company
EQUIPMENT FOR SEMI-MICRO CHEMISTRY

Experimental and Theoretical

Aspects of Diamagnetism

● By William A. Lynch, Ph.D., *(New York University)*
DEPARTMENT OF PHYSICS, NEW YORK UNIVERSITY

When inquiry is made concerning research in some of our schools we hear complaints of lack of money, and lack of time, and much discussion of the difficulties of selecting suitable and interesting problems.

Here are some practical suggestions for research of importance that can be carried out in any physics laboratory with a minimum of apparatus and expense.

Dr. Lynch's discussion of the important facts of diamagnetism and of what has already been accomplished should stimulate some of our teachers to begin work in this field.

●

Modern textbooks in physics explain in detail the principles of permanent magnetism in terms of ferromagnetic substances, give extensive data about these substances, and describe at length the many interesting and instructive experiments that can be performed with them. In general, however, the textbooks dismiss the subject of diamagnetism with merely a sentence or two; the result is that students and sometimes instructors never realize the important part played by diamagnetism in the whole theory of magnetism, and never perform or see performed the beautiful and yet simple experiments that give insight into the very nature of magnetism and of matter itself. It is my purpose to recall some of these experiments that they may serve, perhaps, to inspire some to investigate the phenomena for themselves; investigations of this kind can be carried out in any physics laboratory with a minimum of apparatus and expense, and yet the results to be obtained may be of fundamental importance to the theories of magnetism and matter.

Diamagnetism was discovered by Faraday on November 4, 1845; the experiment as described in his diary consisted of suspending a short bar of heavy glass "1 6/8 of an inch long" by cocoon silk between the poles of a powerful electromagnet; the axis of the bar was at an angle of about 45° with the axis of the magnet when in the rest position. When the magnet was energized, the bar swung to the "equatorial" position i.e., with its axis at 90° to the field; a paramagnetic substance would have assumed the "axial" position i.e., parallel to the field, Fig. 1. Furthermore, the glass bar moved directly to the equatorial position regardless of the original orientation of the ends of the bar, that is, the bar could be changed end for end without affecting its tendency to move to the nearest equatorial position; this showed that there were no permanent poles in the bar, and the effect disappeared as soon as the magnetic field was removed. Faraday also discovered that if the bar was carefully mounted with its axis in the axial position, it remained in that position when the electromagnet current was turned on; these results convinced Faraday that the phenomenon "was not due to particular ends of the glass but to the whole mass."

These experiments are repeated best by the use of bismuth, the most strongly diamagnetic substance known; its properties were thoroughly investigated by Faraday in a continuation of the research described above. A small pellet of bismuth is suspended near one pole of an electromagnet, and the current is turned on; the bismuth is repelled. The polarity of the electromagnet is reversed and again the bismuth is repelled. We see from this experiment that in diamagnetic bodies the induced pole is the same as the inducing pole, and the diamagnetic substance is driven from the stronger to the weaker part of the magnetic field. A small cylinder of bismuth is then suspended between the poles of the electromagnet; if the pole pieces are

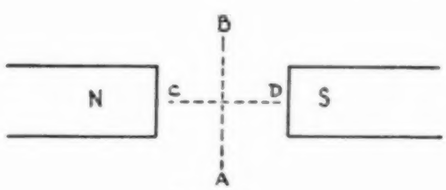

FIGURE 1
A B. EQUATORIAL POSITION. C D. AXIAL POSITION.

conical or shaped so that the magnetic field between them is non-uniform, the bismuth needle sets itself perpendicular to the field in the equatorial position. This result is in accord with the generalization stated above that the induced poles tend to move from the stronger to the weaker parts of the field. Suppose now that broad, flat pole pieces are used so that the magnetic field between them is straight and uniform; it may be possible then to start with the bismuth needle in the axial position and have it maintain that position when the current is turned on. Faraday found that the position was unstable and that any slight obliquity of the needle with respect to the field caused the needle to take up the equatorial position; any lack of uniformity, too, in the field causes the bismuth to move across the field. This is an interesting point because authorities seem to disagree on how the needle will act in the uniform field. J. J. Thomson in his *Elements of Electricity and Magnetism* mantains that in a strictly uniform field a diamagnetic needle sets itself parallel to the field even though it starts in the oblique position; in Poynting and Thomson's *Electricity and Magnetism,* he gives a different proof of the same statement. Williams in *Magnetic Phenomena* states unequivocally that a diamagnetic rod always sets itself

perpendicular to the field; Loeb in the *Kinetic Theory of Gases* says such a rod takes up the perpendicular position in a uniform field. Perhaps some reader will duplicate Faraday's success in obtaining the unstable position with the bismuth needle; he should then attempt to verify Thomson's statement by the use of very large, flat pole pieces. Settlement of this question is not important for our further discussion, as invariably we shall be dealing with fields that are quite non-uniform.

FIGURE 2
A. DIAMAGNETIC LIQUID. B. PARAMAGNETIC LIQUID.

The behavior of diamagnetic bodies in magnetic fields is best demonstrated to a class or audience by optical projection. Small needles of bismuth and glass, for example, are used in order that the pole pieces can be kept close together; the fields then are intense and the action prompt and decisive. Needles of iron, nickel and aluminum should also be placed in the field to show how substances of varying degrees of paramagnetism compare with the diamagnetic bodies. I shall not attempt to describe in detail methods of optical projection; each demonstrator must decide for himself how he is going to put on his show in order to obtain the best results with his own apparatus. I like to demonstrate these effects using very simple optical trains so that all parts of the apparatus are clearly seen and their functions obvious. I must confess that I am intrigued by the behavior of bismuth in the magnetic field each time that I see it.

Before describing more precise experiments that lead to quantitative results, I feel that it is necessary to discuss several technical aspects of magnetism in general, and to offer some explanation of why the various substances behave as they do in the magnetic field; these explanations will be given in terms of modern theories of electricity and matter. We have already distinguished indirectly between diamagnetic substances and paramagnetic substances; the former tend to move from the stronger to the weaker parts of a magnetic field, the latter from weaker to stronger; the diamagnetic needles set themselves perpendicular to the field, the paramagnetic parallel to the field. These differences are brought out in another way by introducing the term permeability. The force between two magnetic poles is determined by the strengths of the poles, by the inverse square of the distance between them and also by the surrounding medium; if the medium is paramagnetic the force is less than that in a vacuum, while if the medium is diamagnetic the force is greater. We say that the permeability of the paramagnetic medium is greater than one, that of the diamagnetic medium is less than one, while the permeability of the vacuum is unity. A ferromagnetic body is paramagnetic with a very large value for the permeability.

A useful way of visualizing the effect of the permeability of a substance is in terms of the lines of magnetic force. If a paramagnetic body is placed in a magnetic field in vaccuum, the lines of force tend to crowd into the body; the extent of this concentration as compared to the original concentration before the paramagnetic body was introduced, measures the permeability of the body. When a diamagnetic body is brought into the field, however, the lines of force tend to avoid the body and keep in the empty space instead; the concentration is less in the region occupied by the diamagnetic body after its introduction than before, and the permeability is less than one. The permeability of the air is very slightly greater than that of empty space and often its value is taken as unity for convenience; comparisons are then made with air as the standard medium rather than with vacuum.

The properties of magnetic substances are also described in terms of susceptibility. Suppose a small block of soft iron, which originally shows no poles, is placed in a magnetic field; it becomes magnetized by induction. The lines of the field crowd into the iron, and give rise to a south pole where they enter the iron and a north pole where they leave. The pole strength per unit area of the induced pole is a measure of the degree to which the iron has been magnetized by the applied field; but the pole strength per unit area is

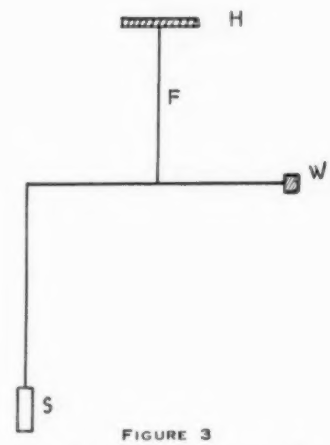

FIGURE 3
H. TORSION HEAD. F. FIBRE.
S. SPECIMEN. W. COUNTERPOISE.

the same as the magnetic moment per unit volume, if the block has been magnetized uniformly throughout. The magnetic moment of a magnet is the product of the strength of either pole and the distance between poles. We call the magnetic moment per unit volume of the block the intensity of magnetization, and usually represent it by the letter I. We see that I measures the density of magnetism spread uniformly through the block. But I arises from the fact that the block was placed in the external field of strength H; the ratio of I to H is the susceptibility of the block, and is usually represented by k. The susceptibility of a substance measures its tendency to assume the magnetic state under an applied stimulus.

A close connection exists between the permeability μ of a substance and its susceptibility k; it is found that that the relation is

$$\mu = 1 + 4\pi k$$

For a paramagnetic substance μ is always greater than one so k is always positive; but for diamagnetic substances μ is less than one and k is negative. The negative sign is a reminder that diamagnetic bodies are magnetized in the opposite sense to paramagnetic bodies when placed in external magnetic fields. The table below gives values of k for several substances; susceptibilities are sometimes given in terms of unit mass; these are obtained from the table by dividing the value of k by the density of the substance.

TABLE OF SUSCEPTIBILITIES

Paramagnetic Substance	k	Diamagnetic Substance	k
Platinum	20×10^{-6}	Bismuth	-13.0×10^{-6}
Aluminum	1.7	Silver	-1.5
Oxygen	0.16	Glass	-0.9
Air	0.032	Water	-0.72
Carbon Dioxide	0.017	Hydrogen	-0.024

Ewing's method of explaining the behavior of ferromagnetic substances in external magnetic fields is probably familiar to all; he assumed that elementary magnets are present in such substances which are oriented at random when the substance is unmagnetized. When an external magnetic field is applied, the elementary magnets align themselves parallel to the field and produce increased effects; Ewing was able to account for hysteresis and residual magnetism in terms of his model of the ferromagnetic substance. He was not able to explain the actions of diamagnetic bodies on the same scheme, and we have to turn to the work of others to seek an explanation. Ampere in 1823 suggested that magnetic effects are due entirely to circulating electric currents within materials; his suggestion was elaborated by Weber in 1845, and brought in line with modern theories by Langevin in 1905. According to Langevin, the magnetic properties of all matter are due to electrons revolving in orbits within the atoms. A single electron rotating in a closed ring is equivalent to a current circulating in a wire; it sets up a magnetic field in the vicinity that can be calculated in terms of the strength of the current and the radius of the ring. Ampere looked upon such circuits as equivalent to thin shells of magnetic material of the same area as the circuit and with definite magnetic moments; in this sense a magnetic moment is considered a vector quantity as there is a definite direction associated with the axis of each shell. Atoms generally contain several rings of electrons, and the total magnetic moment of each atom is the vector sum of the magnetic moments of the separate rings; if this vector sum is greater than zero, the atom as a whole is equivalent to a small magnet. On Langevin's theory, the substance composed of these atoms is paramagnetic. But if the vector sum is zero, there is no resultant magnetic moment of the atom; the atom can never show permanent magnetic properties. However, an external magnetic field applied to the atom will affect the magnetic moments of the separate rings of electrons; and the final outcome depends on the orientation of the axes of the rings with respect to the external field. Those rings of electrons with their axes in the same direction as the magnetic field have their magnetic moments reduced, while those with their axes opposite have their magnetic moments increased. Both effects result in the building up of a magnetic moment with its axis opposite to the applied field; this production of an opposite magnetic moment is called diamagnetism; the substance in which this happens is diamagnetic.

Perhaps a few words of explanation are necessary at this point to account for the changes in the magnetic moments of the electron rings under the action of the external field; a clear understanding of this action should remove all difficulties associated with the whole subject. Suppose an electron is rotating clockwise in its orbit in the plane of this paper; it is equivalent to a conduction current flowing in a counter clockwise direction in the same orbit, and its magnetic moment is proportional to the current and the area within the orbit. Now apply a magnetic field directed downward and perpendicular to the paper. While the field is building up to its final value, an induced electromotive force is set up around the orbit in the counter-clockwise direction, and the electron is accelerated in its path. By the time the field has become steady, the electron is moving more rapidly than it was before; but this means an increase in the current and hence an increase in the magnetic moment of the orbit. The applied field has the opposite effect on an electron revolving in its orbit in a counter clockwise sense. Suppose further that the field is removed; all the actions are reversed; those electrons that had been speeded up

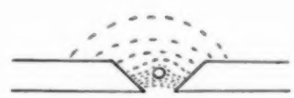

FIGURE 4
SPECIMEN IN NON-UNIFORM FIELD.

slown down to their former velocities; those that had been slowed down speed up, and the total magnetic moment of the atom returns to its zero value.

One further point remains to be made. We have seen that in a paramagnetic substance, each atom has a resultant magnetic moment; but with no applied field the atoms are oriented at random due to their thermal motions and the body is unmagnetized. Apply an external magnetic field and the effect is twofold: the field tends to line up the atomic magnets with their axes parallel to its own direction and hence give a positive magnetic moment to the mass of atoms; at the same time it produces the diamagnetic effect in the separate atoms and thus decreases the positive

magnetic moment. The second result, however, is very small compared to the first and is entirely masked by it; diamagnetism is present but we observe paramagnetism. It was in this manner that Langevin was able to modify Faraday's statement about the universality of magnetism; diamagnetism is the magnetic property common to all substances.

We see now why the pellet of bismuth is repelled from a magnetic pole regardless of whether the latter is north or south; the magnetic moment of the bismuth atom is directed opposite to the field so that the induced pole on the side of the pellet toward the inducing pole is always of the same kind as the latter. The bismuth needle in the non-uniform field has temporary poles induced at its ends which cause a torque to be set up, rotating the needle to the equatorial position; in this position, of course, the induced poles at the ends disappear and new ones appear on the sides. It may be a little difficult to understand, then, why the needle is in stable equilibrium in the equatorial position; we can make use of a general theorem in me-

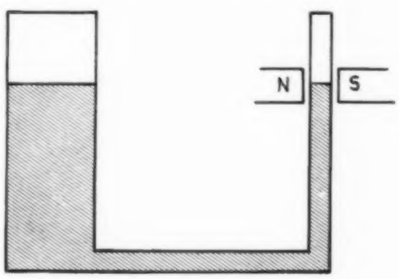

FIGURE 5
QUINCKE'S APPARATUS.

chanics that will assist us and at the same time throw new light on the whole phenomenon. This theorem states that when a system is in stable equilibrium, its potential energy is a minimum. The energy per unit volume of a body in a magnetic field is $\mu H^2/8\pi$ where μ is the permeability of the body, and H is the strength of the magnetic field within the body. Suppose that we have a non-uniform magnetic field in air, the permeability of which is taken as unity; a paramagnetic substance placed anywhere in the field causes a reduction of energy in that region since the field within the substance is less than the original field in air by a factor μ; the paramagnetic substance causes the greatest change in the region where the field is greatest. Therefore, in the non-uniform field, forces and torques appear causing the substance to move to the strongest part of the field. If the paramagnetic body is in the form of a needle, it takes up the axial position so that all of its volume is in the strongest part of the field. If the field is uniform, the energy per unit volume is the same regardless of where the body is situated; therefore no resultant force acts on the paramagnetic substance in the uniform field. Suppose now that a diamagnetic body is placed in the non-uniform field; its permeability is less than unity and the energy of body and surrounding air is least when the body is in the weakest part of the field; forces and torques are set up to accomplish this result. If the diamagnetic body is in the form of a needle, it takes up the equatorial position so that most of its volume is in the weak parts of the field with only a small portion in the strong part. In the uniform field no resultant force arises because the energy is the same per unit volume for all parts of the field.

A striking experiment that illustrates the tendency of diamagnetic substances to move from the stronger to the weaker parts of the field, while paramagnetic substances do just the opposite, is that devised by Plücker. He placed a watch glass containing a liquid on the poles of a powerful magnet; the level of the surface was disturbed in a manner determined by the nature of the liquid. If the liquid were diamagnetic, say water, then its section is indicated by Fig. 2a; the water moved from the center away from the strongest part of the field. If the liquid were paramagnetic, a solution of nickel sulphate for example, then its section is shown by Fig. 2b; the liquid piled up in the strongest part of the field. These results occur when the poles are about 1/10 inch apart; if they are widely separated, the strongest parts of the field lie close to the pole pieces and just opposite results should be obtained.

We are ready now to appreciate the experiments performed by Faraday to measure the susceptibilities of various diamagnetic substances; he used what amounts to a delicate magnetic torsion balance by suspending a cross arm by means of a long fibre from a torsion head. The specimen to be investigated was suspended from one end of the cross arm; a weight was fastened to the other end to act as a counterpoise, Fig. 3. The specimen *S* was hung in a field due to pole pieces shaped to give an intense but non-uniform field; the cross section of pole pieces and field was approximately as in Fig. 4. The force urging the diamagnetic substance out of the field was obtained by turning the head *H* until the specimen *S* was brought back to its original position before the electromagnet was energized; the value of the susceptibility was obtained in terms of water in air as a standard. This method has been modified by various experimenters; it was essentially this method that was used by Curie in 1895 in an extended study of the whole field of dia- and paramagnetic bodies. He was very careful to suspend the specimen at the point in the field where the product of field strength and rate of variation of the field was a maximum; the result was that the force was constant during the slight displacement of the body; the displacement was observed by means of a micrometer microscope.

Plücker's experiment described above has been used as the basis of a precision method for determining the susceptibility of liquids; the method was devised by Quincke in 1885 and has been used with modifications in many researches since then. The apparatus is essentially an hydrostatic balance consisting of a *U* tube with one limb narrow, about 6 mm. in diameter, and the

other wide, about 6 cm. in diameter, Fig. 5; the narrow limb is placed between the poles of an electromagnet capable of establishing an intense magnetic field. The liquid to be examined is poured into the tube until the surface rises to the center of the field; its level is observed by a micrometer microscope. When the field is put on, the level in the narrow limb rises if the liquid is paramagnetic and falls if the liquid is diamagnetic. The force is calculated in terms of the change in level and the density of the liquid, and also in terms of the susceptibilities of the air and the liquid.

We have cleared the way now for a discussion of the data obtained by the experimenters and a survey of what can be done by those who are willing to devote the time and effort to carry on the work of seeking more information. Our study of diamagnetism has shown us that it is an atomic property common to all matter; hence measurements of susceptibility give us an insight into the structure of the atom itself. The first conclusive evidence that diamagnetism is a true atomic property came from Curie's work; he showed that the susceptibility of diamagnetic substances is independent of the temperature, while that of paramagnetic substances decreases as the temperature rises. If the magnetic moment of the atom is zero, thermal agitation will not alter its behavior in a magnetic field; but if the atom has a resultant magnetic moment, the tendency to align itself with an external magnetic field is hindered more and more by heat motions as the temperature rises. Many exceptions have been found to the general results obtained by Curie.

The mathematical theory of diamagnetism, based on the atomic model already discussed, connects the intensity of magnetism with the total number of electrons per unit volume, the mean radius of the atom and the susceptibility. If the mean radius of the atom is assumed known, then the number of electrons revolving in rings in the atom can be computed; the results obtained in this manner show fair agreement with those obtained from spectroscopic data. Loeb gives the following table of values calculated for the mean radii of several atoms in terms of the atomic number Z which is the same as the number of external electrons per atom; K is the mass susceptibility per gram-atom.

Substance	Z	—K	Mean Radius
H	1	2.7×10^{-6}	$.98 \times 10^{-8}$
He	2	2.2	.63
C	6	6.6	.62
Cl	17	22.	.67
Br	35	33.	.58
Hg	80	36.	.40
Bi	83	280.	1 1

The radius of an atom is about 10^{-8} cm.

Stoner has performed the reverse calculation for helium by taking spectroscopic data for the helium atom and obtaining the susceptibility; the calculated value is of the right order of magnitude but smaller than the observed. He improved on the calculation, however, by introducing wave mechanical considerations and obtained the following results for helium and other substances.

Substance	—K Calculated	—K Observed
He	1.9×10^{-6}	1.88×10^{-6}
Ne	8.6	7.1
A	24.8	19.2
Na^+	5.6	5.4
K^+	17.3	13.4
Rb^+	29.5	23.0

I introduce these results to show that the general explanation of diamagnetism is a satisfactory one, but that there are still many details to be worked out for a complete theory. We see from these calculations also the importance of treating susceptibility as the ratio between the intensity of magnetization and field strength; the susceptibility gives us a direct measure of the magnetic moment per unit volume of the substance, which in turn leads us to equivalent circuits and their areas, and thence to numbers of electrons and atomic radii.

The most fascinating branch of the theory deals with the relation between magnetism and chemical properties; this is the part, too, where effective experimental work can be done without expensive equipment by use of Quincke's method. Pascal did the pioneer work in this field in 1912 with a series of experiments on organic compounds; he found that diamagnetic atoms combine to form diamagnetic molecules and that the effects are additive. He concluded that the susceptibility of a molecule can be calculated as the sum of the susceptibilities of the separate atoms, provided a correction is made which depends on the nature of the chemical bonds between the atoms. His calculated results for molecules agreed with his measured values with an accuracy of 1 or 2 per cent. Further study of his results and continuation of his experiments may throw additional light on the subject of the structure of molecules and the mechanism of chemical combination.

The susceptibility of an ion can be obtained by measuring the susceptibility of salt solutions of various concentrations containing the ion; these measurements lead to results characteristic of the atom stripped of one or more electrons or containing one or more extra electrons; comparison between theory and observation can be made in terms of the original atom and also in terms of the atoms above or below it in atomic number. For example, if the susceptibilities of K and Cl^- are obtained in KCl, they can be correlated with that of argon. Argon has the atomic number 18, while potassium has 19 and chlorine 17; the potassium ion K^+ however should behave magnetically in the same

Continued on Page Eighty-five

Making a Microscope

● By Kenneth G. Niblack
MECHANICAL DESIGNER, BAUSCH & LOMB OPTICAL COMPANY

To care properly for the school's microscopes is the duty of the science teacher. He should know something about how they are made. He should understand how to clean, adjust and store them so as to lengthen their lives.

Mr. Niblack, who has had a number of years' experience in the construction of microscopes, here presents some valuable information. Reading this article may help the teacher to avoid errors both of omission and commission.

●

The microscope, a tool of human progress, has had a spectacular rise from small beginnings in the hands of the original investigators, such as Anton von Leeuwenhoek, through years of scientific investigation, development and discovery, to important present-day, routine applications. It has played an important part in the development of our civilization. It is in constant use in the doctor's office, in the hospital, and in innumerable research laboratories where everything from food to metals is investigated.

The microscope is the most important tool of the metallographer in his inspection of metals. It is used in the machine shop laboratory for measurement and projection. Even clothing is improved through constant examination with the microscope. Continued investigations of fiber—textile and paper—have led to improvements in these fields. A better knowledge of organic and inorganic materials seems to have led to almost as many advances as has the study of life in the biological and bacteriological laboratories.

MAGNIFICATION

The microscope is an interesting instrument. The tremendous magnification obtained strikes the uninitiated as a work of magic. On the contrary, the refracting of light rays by suitably shaped glass,—the complex, mathematical formulas involved in an optical system that produces a good image many times enlarged,—combine the processes of exact physical science with the most skilful workmanship. Greater magnification is obtained by placing an article closer to the eye. Of course, some means has to be devised to permit the eye to focus on such a close object, since we cannot normally focus on objects which are held near to the eye. Van Leeuwenhoek, one of the first men to grind lenses of sufficient power to give really high magnification, used a single very tiny lens, that he held close to his eye. (Fig. 1.) Since his was a very difficult instrument to use and required considerable dexterity, many men attempted to find a way of using the tiny powerful lens in a more comfortable and convenient manner.

The compound microscope of today is a result of their work. A powerful lens is located at the bottom of a tube, with a series of lenses between it and the eye computed to bring the image to focus on the retina of the eye. There are, of course, many combinations to give different magnifications. The usual system is divided into two parts, the objective and the eyepiece. Since illumination of the object is one of the most important phases of microscopy, a method was evolved to accomplish this purpose by constructing the substage condenser to control the amount of light and the angle in properly illuminating the specimen.

FIGURE 1
A MODEL OF THE FIRST MICROSCOPE.

A MACHINE TO HOLD THE GLASS AND CRYSTAL

In the first microscopes a crude method was used to hold the specimen at the proper distance from the lens. Improvements designed to make the manipulation easier finally resulted in a common form, very similar to the form of a vise, which holds the specimen rigidly at the proper distance from the lens. To provide for focusing the different powers of objectives, a rack-and-pinion coarse adjustment is usually employed. A fine adjustment is desirable for the use of high-power objectives. One end of the vise-like arm holds the body tube. The other end holds the stage on which the specimen is placed or manipulated, and under which are the illuminating condenser and the mirror. The entire equipment is supported on a base, often in the form of a horseshoe, usually hinged to the lower end of the arm. This hinge, or inclination joint, permits the instrument to be tilted to a convenient working position, or to a horizontal position for photomicrography or projection.

Various accessories have been devised from time to time to make microscopes more convenient and to make microscopic work more comfortable. Among these, the

mechanical stage is considered one of the most essential. It jermits the movement of objects in two directions by means of a slow-motion mechanism. The revolving stage has been devised for work in polarized light, for determining optical characteristics of crystals. An inclined binocular body tube is in general use, to provide a comfortable operating position. The binocular eyepiece permits using both eyes, giving an increased visual acuity as well as reducing eye-strain. Several refinements in the substage have been developed to improve working conditions, some of which are essential to really fine work. There are the rack and pinion focusing adjustment; a rotating and decentering iris diaphragm, and facilities for changing to different types of condensers for different kinds of work.

WE NEED LIGHT TO SEE

Illumination for microscopy depends upon the type of work being done. For extremely critical work, a precisely controlled illuminating system is necessary. In the early days of microscopy, a white cloud was the standard source of illumination. Later, various flames and arcs were used. Today, there are three predominant types of microscope illuminators, all of which give uniform brilliancy over an area of sufficient size to be imaged on the specimen.

The crater of an arc light is one of the most intense sources. It is fairly even. The ribbon filament Mazda lamp has been developed to give a very bright source of even intensity, but the tungsten arc lamp, a recent advancement, promises to be the most efficient light source for microscopy. This lamp has a disc of tungsten surrounded by a loop of wire. The arc is formed by mercury vapor, but the characteristic of the light is that of tungsten. In other words, the white hot disc of tungsten is imaged on the specimen.

MANUFACTURE

In manufacturing a microscope, the most essential thing is good optical parts. A physicist who has specialized in the mathematics of optics will first compute the lens system required to produce a good image at the magnification desired. He will specify glass of the correct index of refraction and dispersion to make his computations come out right. Ceramic chemists then determine the ingredients necessary to make glass to meet these characteristics. The ingredients are mixed, poured into a specially prepared crucible, and melted. The melted glass is stirred slowly for a considerable time. When all ingredients are thoroughly mixed and the glass has reached the proper temperature, it is removed from the furnace and placed in a special annealing oven, where it is allowed to cool slowly for many days. When the glass is thoroughly cooled, it is broken up into chunks and examined for specimens of sufficient purity to make optical parts for microscopes.

Selected pieces of glass are heated, pressed into the approximate shape of a lens, and rough ground. Fine grinding is followed by polishing with rouge until the lens is finished and accurate to very small tolerances, tolerances which are measured in millionths of an inch by means of light rays. Finished parts for the compound microscope lenses are cemented together. The lenses are then mounted into metal cells.

The mechanical parts of a microscope originate in the mind of the designer. They first appear on tracing paper. Blueprints are made and a sample is made up in an experimental instrument shop, so that actual dem-

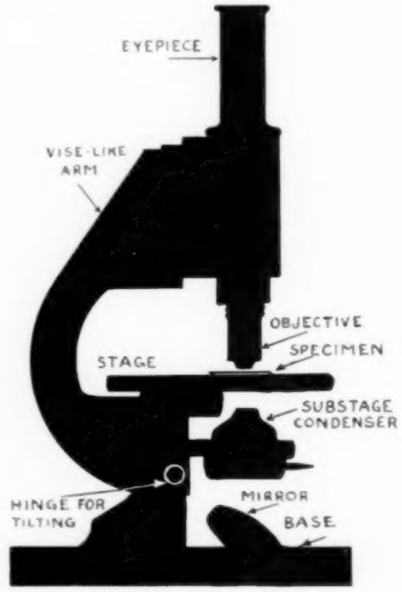

FIGURE 2
A CROSS-SECTION OF A MODERN MICROSCOPE.

onstrations can prove its mechanical efficiency and convenience. When the final model has been approved, detailed drawings of each separate part are presented to the production department, which schedules the work of manufacturing. Although many special machines have been designed and built to perform work on microscope parts considerable hand work still is necessary.

Microscope parts are made of many different materials including cast-iron, nickel-iron, bronze, brass, nickel-silver, aluminum, steel, and mica. Altogether, there are approximately 300 parts made up of tubes, bars, sheets, various shapes, castings, forgings, and extruded parts of various compositions.

The parts of a microscope are always finely finished. Many of these finishes are achieved by the use of actual diamonds in the cutting tools, which finish the surfaces so accurately that very little work need be done on working parts. Exterior parts, finished with diamond tools, are ready for plating or enameling without further work. The metal finish used on early microscopes was plain black enamel, with a coat of lacquer over the highly-polished brass parts. Today, superior finishes make it possible to quickly complete an instrument in a special satin black enamel, and a brilliant chromium plate, both of which are durable and reagent proof throughout. The fine finish used on modern microscopes will last without a great deal of attention and care.

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Changing Viewpoints in
Teaching High School Biology

● **By Sister M. Dafrose, O.P., Ph.D.,** *(Fordham University)*
CHAIRMAN, SCIENCE DEPARTMENT, THE BISHOP McDONNELL MEMORIAL HIGH SCHOOL, BROOKLYN.

Sister Dafrose here concludes her interesting study of one hundred years of progress and change in the teaching of biology in secondary schools.

In the June number she discussed the natural history, and the anatomical and morphological periods. Sister Dafrose now continues her discussion of the recent period of correlation and application, the period which led to the unit plan of today.

Every teacher will be interested in the splendid aims and objectives for biology instructors that are here listed.

●

PART II.

Peabody and Hunt bear further witness to the changed viewpoint in the preface of their book *Elementary Biology* (Macmillan, 1912), when they state that:

"In the judgment of the authors the kind of biology most worth while for the average boy or girl of fourteen years of age is *not one based primarily on structure*. Young students are naturally more interested in activities or functions than they are in mere form or structure. Hence, if we wish to work with, rather than "against the grain," we must put function in the foreground of our discussion. Every boy and girl knows, too, that both plants and animals as well as human beings must have food and drink, and that they grow and reproduce their kind. It is relatively much easier, therefore, to unify a course like this along physiological lines than on the basis of morphology, or of homologies of structure, many of which are far too complicated to be made clear to young students.

If properly outlined and presented, there is probably no subject in the school curriculum that can be made of more service to a growing youth than can biology. Biological problems confront him at every turn, and if he is a normal being, he will have asked himself question after question which an elementary knowledge of biology ought to help him to answer. Some of these questions may be the following: Whence comes the food and oxygen supply used by man? Why are food and oxygen needed in our bodies? Why are some substances beneficial to the body and others injurious? What is the cause of disease, and how is disease transmitted? And if we were to tabulate the biological questions that occur spontaneously to the average pupil in the first year in the high school, we should doubtless find that a great proportion of these questions had to do with the relation of the living world to human life. Is it not clear, therefore, if we are to outline a course in biology that will best fit the interests of the "live material," i.e., the boy or girl who is to take the course, that the central idea or factor must be man; that all the various functions considered must have some relation to human life; and that the course, to be of practical importance, must suggest to the youth better ways of carrying on his own life and of helping to improve the surroundings in which he lives?"

There was in this period a decided gain in interest in biology among high school students and a definite attempt to have the biological laboratory function as a place where students could see and handle and experiment with living plants and animals. This removed the study of biology from the level of studying "pickled and preserved" plants and animals to a miniature "Botanical Garden" and "Zoo" where students could see, take care of, handle, observe, and experiment with, living things at close range.

Progress had been made. There existed, however, the dissatisfaction which is inherent in those who realize what science ought to be able to do for the individual. The need of unifying the study of living things by applying the fundamental principles common to all living things, to coordinate the course in biology, urged Arthur G. Clement, at the time Supervisor of Biological Sciences in Secondary Schools in New York State, to write a text built on these principles: *Living Things* (Iroquois Publishing Co., Syracuse, N. Y., 1924). He states his aims thus in the Preface:

"Biology is the study of living things. The word was first used in the early part of the nineteenth century by Gottfried Treviranus, a German writer on topics relating to life science. He employed the word to designate all the sciences that deal with the phenomena of life.

All the life processes, or functions of living things, may be listed under three headings. In the first group are the processes by which individuals relate themselves to the outside world. These include sight, hearing, touch, taste, smell and motion. They may be called functions of relation. In the second group are the processes involved in producing energy and promoting growth. These include respiration, food-taking, digestion, absorption, circulation and assimilation. They are commonly known as functions of nutrition. In the third group are the processes that pertain to the continuation of the species, namely, the reproductive functions. Since these life processes are common to all living things, they form a logical and convenient basis of unity, quite readily understood. Accordingly, in this book, the several phases of the study of living things will be thus held together and unified.

It is the conviction of the author that a first-year high school course in biologic science should be based on the conception of biology as a single science rather than as three entirely separate courses in zoology, physiology, and botany. It should be one of the purposes of a biology course to teach the great ideas or principles that underly all life. The best way to assure this is to ascertain as soon as

possible what these principles are and then to explain their workings as applied to animals, plants, and man."

Peabody and Hunt, revising their text about the same time, (1924), state in their Preface:

"Twenty years ago, the authors, in common with many other earnest teachers of biology, became convinced that much more emphasis should be placed on the functions of living organisms as contrasted with their structure and that a comparative study should be made of plants, animals, and the human body. These two aims were prominent in our Elementary Biology published in 1912, in which Part I was devoted to plants; Part II, to animals, and Part III, to the human body.

"Biology and Human Welfare" represents the development of our ideas, based on the observation and experience of ten years and more since the publication of the earlier book, and of the best means of realizing these aims. This is a new book, made on a new plan of organization, with distinctive features, some of which are as follows:

1. We have become convinced that a given function, for example, digestion or respiration, can be presented more effectively by considering in turn how the process is carried on in plants, animals, and man as separate units and completing the study of one before taking up the study of the others. Adolescent boys and girls are most interested in those facts and principles of biology that relate closely to themselves. Therefore, to defer a discussion of human biology to the last part of the course results in a distinct loss of interest on the part of the pupils and prevents the immediate and effective application to human life of the various principles derived from a laboratory study of plants and animals. In studying the special function in the three spheres, boys and girls are led to see the essential likenesses in the work done by all living things rather than relatively unessential differences in structure.

2. The dominating purpose throughout this book is to show the intimate relation of biological science to human welfare."

THE "UNIT PLAN"

Science Education is a dynamic, not a static process; so throughout the decade 1924-1934 new viewpoints came to the forefront, crystallizing in the Unit Plan that now holds the center of the stage in science education as in so many other subjects. This was the period that witnessed the unprecedented influx of students into the high school. In 1900 the enrolment was about 500,000, in 1910 about 800,000, in 1920 over 2,000,000 and in 1930 over 4,000,000. The school population was now less homogeneous, the pupil's environment had changed, the economic situation was different; consequently, the needs of the students were different. An older philosophy of education rested on the idea that education was concerned solely with "after school life." The newer philosophy, as well as pragmatic and practical considerations, regarded education as a living experience. "Life after school age" was not to be ignored, but there was demanded consideration of the student himself as a growing organism who must adjust himself to a changing environment, and consideration of the student's present interests and needs also. A new attack seemed to be called for to continue educational progress in scientific education.

The *Thirty-first Yearbook of the National Society for the Study of Education*, (1932, p. 238), expresses the new point of view thus:

"It is desirable to organize the work of biology in definite teaching units. By a unit is meant a relatively small mass of learning material, so selected and organized as (1) to clarify a principle and afford abundant drill in its application to such problems as arise in life, (2) to contribute to the attainment of scientific attitudes, and (3) to give abundant practice in the use of the elements and safeguards of scientific thinking.

The success of a given unit can be assured only when the ends to be achieved by its use are clear to the teacher, when their achievement is tested, and when the pupils are conscious of their accomplishment."

Wilbur L. Beauchamp (Monograph 22, of the National Survey of Secondary Education: *Instruction in Science*, 1932) writes on the Unit Method of Organization:

P. 19.—"Since few, if any, of the courses appearing before 1926 were divided into what were referred to as units, it is probably a safe assumption that the widespread use of term 'unit' after this date in courses of study is due to Prof. H. C. Morrison. Professor Morrison's book *The Practice of Teaching in Secondary Schools*, appeared in that year. According to Professor Morrison, a learning unit may be defined as a 'comprehensive and significant aspect of the environment, of an organized science, of an art, or of conduct, which being learned results in an adaptation in personality."

P. 21.—"In the special sciences, physics, chemistry, and biology, the unit is 'a comprehensive and significant principle or complex of principles and the meaning and bearing of the terms "comprehensive" and "significant" are the same as before."

P. 193.—"The critical test of any unit in the science type is, Does it tend to contribute understanding rather than a descriptive account?"

Charles J. Pieper and Wilbur L. Beauchamp were among the first to present a text written according to the Unit Plan in their *Everyday Problems in Science* (Scott-Foresman, 1925) to which Henry C. Morrison wrote in the General Preface:

"The contributions of science study to present-day life are so manifold and important that we have come to speak of this age as the age of science. Everywhere, in the home, the school, the playground, the workshop, and the community in general, the phenomena and applications of science influence our lives. Citizens of today can better understand, enjoy, appreciate, and control their environment, and adjust themselves to it, through knowledge of the science involved in the daily problems of sensible, happy, healthful, comfortable, and efficient living. Their intellectual, moral, and ethical character depends in part upon their understanding of and their attitude toward the forces and materials of nature.

Our boys and girls grow up in this scientific age and become the citizens of the next generation. At the adolescent period their natural interest in the environment creates a desire and demand to know something of the great contributions of science to modern life and to human progress; their near approach to adult citizenship makes the need for science knowledge and for correct attitudes toward

science problems imperative. They must be acquainted with and have training in the proper methods of thinking about such problems, so that they may be able to do such thinking for themselves.

The immediate aim of science instruction in the years following the elementary school period is, therefore, the broadening of the youth's experiences with the forces and materials of his environment and the developing of an attitude of openmindedness and a spirit of inquiry concerning the nature, value and use of science in modern life. Along with this experience-getting and attitude-forming come the power and inclination to do effectively what civilization demands of every citizen. And out of these results grow the appreciation of nature and the cultural and enjoyment values which help to build individuality and character. The ultimate aim of introductory science is, then, the active and wholesome participation in the desirable activities of life, or good citizenship. If science instruction in the early years of high school meets this objective, it will in an equal degree meet the objective of exploring the fields of science, and will thereby stimulate and guide the student in his later study."

Everyday Problems in Biology by Charles J. Pieper, Wilbur L. Beauchamp and Orlin D. Frank was written in 1932. (Scott-Foresman). Here the new point of view is stated thus:

"The guiding principles underlying the construction of the course may be summarized in a few major postulates:

1. Biology is more than information and knowledge concerning living things; it comprises also methods of scientific thinking about and scientific attitudes toward ourselves and our living environment.

2. Life, or living, is primarily a series of functions and activities more or less common to all living things. These activities result in adjustments. The course in biology, then, should be a study of any or all living things, leading to an understanding of the important functions, activities, and adjustments of organisms.

3. The course in biology shall consist of a series of problems involving learning activities, properly motivated and directed by the teacher and carried out by the pupil in such manner that the pupil is led to the understanding of significant biological ideas, to the acquisition of the elements of scientific methods of thinking, and to the attainment of desirable attitudes toward life in its varied manifestations and significances.

4. The learning activities of pupils in biology shall include a wide variety of those kinds of mental and physical activities which are recognized as elements of scientific methods of thought and which make use of various sources of data as a basis for the solution of worthwhile problems.

5. Biology aims to improve human behaviors in and adjustments to the living and physical environment; it is essential, therefore, that the pupil study both himself and his environment to the end that his behaviors be conscious, meaningful and fruitful."

Fitzpatrick and Horton, in one of the latest texts in *Biology* (Houghton Mifflin Company, 1935) wrote:

"An attempt has been made to emphasize those biological principles which have applications in everyday experiences. The selection of materials has been guided by the results of research studies, insofar as such studies are able to supply data. The field of human experience, however, has not been adequately explored. The textbook writer must necessarily be guided to some extent by his own judgment, and by the results of testing teaching materials in the schools.

The materials of the book have been arranged in seven units. Each unit deals with a specific, fundamental principle of biology. The first unit serves as a general introduction. It includes a discussion of the changing environment and the history of human progress in that environment. The second unit deals with the cell principle as exhibited by the structures of plants and animals. Physiology, considered as representing energy phenomena, is the subject of the third unit. Adaptations of function and structure are discussed in the fourth unit. The fifth unit deals with reproduction in plants and animals. This is followed by a sixth unit on variation and heredity. The seventh unit has as its subject the consideration of other organisms in relationship to human welfare.

Thus, each unit provides student activities and experiences which relate to a basic concept or group of concepts in the field of biology. Throughout the book, also, certain unifying themes develop and become more meaningful with growing experience. These include:

1. The interrelationships of organisms.
2. Specialization and division of labor among cells.
3. The unity and the diversity of life.
4. Life as an energy phenomenon.
5. Adaptations of behavior and structure.
6. Biological control of undesirable organisms."

All these progressive points of view in the teaching of high school biology have one point in common. All are striving to inculcate in high school students the scientific attitude by trying to present a world of life, a world of beauty, a world of change for better living. All to a greater or less extent call for the expansion of the element of appreciation of life, the arousing of a sense of admiration and wonder, the excitation of emotions, the development of the power of accurate observation, the desire for truth, and the courage to follow the truth. They want to arouse students to begin to wonder, then to think correctly, then to develop a true philosophy, which will influence their conduct to attain to an openmindedness and unselfish service which will make them tolerant and respectable members of society.

If a teacher of biology actually succeeds (and who has greater facilities at his command than the Catholic teacher of biology with his definite religious and moral principles to aid him?) in causing high school students studying biology to come into the possession, at least to some slight degree, of such qualities as:

1. To wonder about how and why things happen.
2. To have a high regard and respect for truth.
3. To maintain a critical attitude toward both their own work and that of others.
4. To suspend decision while examining facts.
5. To form conclusions on the basis of evidence not upon the basis of opinion.

6. To keep an open mind ready to change a belief if presented with facts that disprove this belief.
7. To attempt to keep the intellect free from bias or prejudice.

To which, the Catholic teacher of biology should add

8. The recognition of the fact that in the natural order God has ordained that every effect is due to a cause.
9. That there is another order beside the natural order, the supernatural order in which religion teaches man what God has revealed.
10. That science has solved and can solve so called "mysteries" about natural phenomena, but that true mysteries are religious truths that cannot be solved.
11. The establishment of a balanced outlook on life which maintains a proper mental perspective about the relative values of man's body and soul.

It must not be forgotten that the teacher of biology in high school is meeting young students, and that it is impossible to expect that they will emerge from the one year course in biology as full fledged scientific research workers. Nevertheless it is an ideal to be aimed at, and if the biology teacher could actually succeed in causing the scientific method so to become a part of the mental outlook of the boys and girls who throng our high schools as to influence their manifold activities in school as well as throughout life, there would probably be created within a few school generations a new moral and intellectual world—a theoretical but scarcely a practical possibility.

To conclude in the words of U. A. Hauber (Religion in the Biology Classroom: *Catholic Educational Review:* p. 218).

"A final consideration is this: Every Catholic teacher will find himself compelled to add a special chapter to his textbook entitled "The Human Soul." This self-conscious spiritual entity is unique in a world of living things. It is intimately associated with the kind of things the biology class has been studying throughout its course, but it is a being apart, different from, and above, all other things known to us. It is found in the body, governs and controls all the activities of the body, is itself profoundly influenced by the body over which it has charge; but it belongs to another, a spiritual world, the consideration of which is outside the field of biology. Both the soul and the body are made by God. The body is governed by natural laws and some of these laws are investigated in the class-room; the soul or mind which investigates itself and its body, also must obey laws, some of them natural, some supernatural; but it has freedom, it is more than a machine, more than a vital principle. It has inherited, so to speak, powers strangely similar to those of its Creator, the power of freely shaping its own destiny and of voluntarily assisting in directing the destiny of others. It is made to the image and likeness of God."

Aspects of Diamagnetism

Continued from Page Seventy-six

manner as argon because it has the same outer electron configuration, the atom having lost one electron to become an ion; the chlorine ion, Cl^-, should behave similarly since the chlorine atom gains an electron in becoming an ion. Interesting results of this type have been obtained by Ikenmeyer with the halides of the alkali and alkali earth metals, but his work should be repeated and extended.

An important series of experiments on complex salts was begun by Rosenbohm in 1919; he was able to connect the magnetic properties of the cobaltammines with the theories of their structure. Cobalt is a ferromagnetic substance and the simple cobalt salts are paramagnetic, but the cobaltammines are diamagnetic; this seems to be due to the fact that the number of electrons associated with the cobalt atom in combination is 36, which corresponds to a closed configuration like that of the inert gas krypton. The magnetic moment of such a closed configuration is zero and the ion or atom is diamagnetic. Rosenbohm measured the susceptibilities of many of these cobalt ammino-compounds, about sixty in all, and found them all to be diamagnetic with the exception of two. He was able to express the molecular susceptibilities in terms of the atomic susceptibilities much as Pascal had done; his correction terms depended on the type of ammino-compound that was being investigated. This whole subject of the magnetic properties of complex salts is just waiting for attention; it seems to open up a field where physicists and chemists can work effectively in collaboration, with mutual benefits to both.

I have attempted to point out the outstanding facts of diamagnetism with the hope that a few may be encouraged to read further and to undertake some of the experiments and investigations for themselves. The subject is not an easy one, but it is rich in possibilities; and each bit of information added to our present stock may aid in the attainment of the final goal of magnetic investigations, which is best described in the words of S. R. Williams: "The determination of what the elementary magnet is, constitutes the fundamental problem in magnetic research."

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Faraday's *Diary*, 7 volumes, and his *Experimental Researches in Electricity*, 3 volumes. These are rich in information and inspiration; they picture vividly the methods of one of the greatest experimenters of all times. They are particularly satisfying to those who are beginning research work because Faraday did not hesitate to describe completely his failures as well as his successes.

J. J. Thomson: *Elements of Electricity and Magnetism*. A standard textbook on the fundamental principles of the mathematical theory. A discussion of the diamagnetic needle in the uniform magnetic field is given on page 210.

Poynting and Thomson: *Electricity and Magnetism*. Useful as a companion volume to the above as it gives much information on the fundamental

experiments. A different discussion of the diamagnetic needle in a uniform field is given on page 258.

Starling: *Electricity and Magnetism.*

Page and Adams: *Principles of Electricity.* Two excellent texts on the whole subject.

Williams: *Magnetic Phenomena.* A survey of magnetism with a judicious selection of theory and experiment, with many suggestions about work still to be done.

Stoner: *Magnetism and Atomic Structure.* A treatise on magnetism from the viewpoint of the quantum theory. Difficult for the non-mathematical reader but contains a great deal of information, particularly about the modern aspects of the subject.

Stoner: *Magnetism.* A summary of the above with special reference to recent work and without the extended mathematical discussions.

Bulletin of the National Research Council, Number 18: *Theories of Magnetism.* Contains interesting historical survey, but not written for the general reader.

Loeb: *Kinetic Theory of Gases.* The standard American textbook on Kinetic Theory; the last two chapters give discussions of applications of kinetic theory to allied topics, among which is diamagnetism.

In Future Numbers . . .

A few of the many interesting articles that will appear in early issues of THE SCIENCE COUNSELOR are listed:

The Teaching of Science in the Elementary School Grades

By Warren W. Knox, Supervisor of Science, New York State Education Department, Albany.

Aims and Objectives of the High School Course in Physics

By Rev. John H. Crawford, O.S.A., Villanova College.

Science in the Professional Education of Teachers

By Helen Heffernan, Chief of the Division of Elementary Education and Rural Schools, California State Department of Education.

The Story of Abrasives

By Duane G. Webster, Norton Company, Worcester, Mass.

Institutum Divi Thomae

By Rev. C. A. Miller, Director.

Visual Aids in the Science Classroom

By Warren Taylor, Central High School, Binghamton, N. Y.

Theories of the Solution of Electrolytes

By Sister Mary Dorcas, Seton Hill College, Greensburg.

Colorimetric Analysis

By B. H. Strom, Technical Editor, Fisher Scientific Company.

A Science Night Program

By Robert Collier, Jr., South High School, Denver.

Purchasing Biological Supplies

By Alden H. Forbes, Laboratory Apparatus Division, W. J. Gilmore Drug Company.

Modern Science Room

Continued from Page Seventy

of suggestions and recommendations of science teachers of the State, school heads, school building architects, educational consultants, and science equipment manufacturers. No elaborate set-up is indicated. However, the details include those things which are believed to be essential for the proper physical and environmental conditions which will directly assist in adapting teaching procedures to individual pupil needs. The room is planned for individual pupil experimentation, teacher demonstration, lecture, discussion recitation or any other type of instruction which may be deemed advisable at any particular time. It is likewise adaptable for the use of the many science clubs which now form a very definite part of the modern school program.

Apparatus is concentrated in one room, thereby tying up more satisfactorily discussion and laboratory work. The room itself is of the standard width, 22 feet, and 41 feet in length, with 18 inches in the rear for cabinet and display cases. The general equipment includes a teacher demonstration desk, together with seven six-pupil tables, 24 inches wide. Chairs with backs no higher than will permit their being fitted under the projection of the top of the table when not in use, are more satisfactory than stools. An advantage of this type table is found in the fact that all pupils face the front. Two sinks each are provided in every other table. Since pupils working at the tables without sinks can secure water from the table next to them, considerable saving in plumbing is effected. Care should be taken in the plumbing installation on the demonstration desk and the pupil tables, so that it will withstand the effect of acids and other corrosive materials.

The Science Table

In the selection of tables, care should be taken so that the tops will prove serviceable. The best quality of hard birch or maple in narrow boards, tongue and groove, glued in order to prevent warping, should form the table tops. If the best material is used, there is little danger of the boards splitting or separating at the joints. The tops should be treated every few years with acid-resisting paint, and several times each year with a good quality of linseed oil, applied hot. The tables when given this attention can be kept in first class condition over a long period of time.

The table (6-b), 2 feet, 7 inches high, and 15 feet in length, constructed with eight legs evenly distributed, is divided into three sections with two drawers in each section. The drawers are 18 inches wide, 15 inches long, and 3½ inches in depth. Gas and electric outlets are supplied on each table. In districts where gas is not available, these fixtures may be omitted, and alcohol burners or other types of heat may be utilized. Recently, commercial gas is being supplied by means of a tank car to districts where gas is not available through a gas main. A tank is placed on the premises

of the person securing this service, and payment is made monthly for the gas as it is consumed.

The Window Shelf

Provision is made on the window side of the room for a window shelf 18 inches wide and approximately 34 inches high. This window shelf is used for weighing materials, for germination projects, for microscopic work, for the display of pupil work, or for any other feature that is so often presented in the science classroom.

Electrical Equipment

Electrical outlets should be placed along the side of the wall so that electrical equipment can be utilized to advantage. They are particularly important in the use of projection apparatus and radio. The place that the radio will fill in the science instruction room is yet to be determined. However, it is possible for much valuable assistance to be secured from the air for classroom instruction. In the larger schools provision should be made for 110 volt direct and alternating current, and battery service for varying voltage.

Equipment for Visual Aids

Ample blackboard space should be provided in the front of the room. Bulletin boards should likewise be abundantly supplied. This might even approximate 24 linear feet. A built-in or movable dictionary stand, and built-in book shelves, approximating 18 linear feet, should be provided. A cabinet, properly sectioned to accommodate the notebooks and other written work of from four to six groups of pupils, is most desirable. Map and chart cases, and adjustable hangers for charts and graphs should likewise be provided at convenient places in the room.

The 18 inch space provided in the rear of the room should be utilized mostly for exhibition purposes. Here projects and collections of work which adolescent youth can be so easily inspired to make can be placed on display. Likewise, it can form the nucleus of a small

museum. Drawers and sections with doors constructed at the bottom portion of this space to a height of approximately 34 inches, are desirable. Every effort should be made so that orderliness and cleanliness, one of the basic principles of science, may be exemplified. A well planned room facilitates the attainment of this goal.

Fume Cabinets

Plan No. 1 also provides for a teacher closet near the front of the room on the corridor side. Another space on the opposite side of the entrance door may be utilized as a fume cabinet. Additional fume cabinets, if deemed necessary, can be secured by limiting the corridor locker space. If desirable, a fume cabinet can be placed in the chemistry storage room. When fume cabinets are included, provision should be made for the removal of the fumes by a mechanical device. Without a serviceable exhaust system it is useless to include fume cabinets in the room. The author's experience in his visitation to the high schools of the State leads him to believe that in most cases these cabinets have been a needless expenditure. Very often these spaces have become a "catch all" for odds and ends. Some college chemistry instructors of note have advocated no fume cabinets since many claim it is unnecessary to perform those few experiments in which obnoxious gases are liberated.

Combination Science-General Shop Room

A few small schools of the State have developed a combination science classroom and general industrial arts shop plan. This unit (6-c) from 45 to 50 feet in length, includes a science layout in the front of the room and a general industrial arts shop layout in the rear. The equipment for the science section follows closely those suggestions in the combination science laboratory-classroom above. Such a plan is not the most desirable and should be used only in schools with very small enrolments and with limited finances.

The Storage Room

Ample storage space must be provided if the science room is to function most effectively. Too many schools are seriously handicapped through its lack. Limited space for the storage of apparatus, chemicals and other science materials has caused unnecessary expenditure in the school budget, due to breakage. If sufficient space is not provided, materials are stored in a haphazard manner so that breakage results and difficulty in finding the materials needed is encountered. Convenience of access, and a systematic placing of the materials are fundamental principles of science. The room indicated on Plan No. 1 as storage, together with the space allocated in the combination classroom-laboratory, should provide sufficient space for the proper storage of science materials in a school requiring up to two rooms for the scheduling of its science classes.

If only one combination classroom-laboratory is required, the storage room should be placed at the front. By this placing, the room is of ready access to the teacher. If two combination classroom-laboratories are required, the storage room should be placed between the two for convenience and for the concentration of all science materials. The room which is used for instruction in the advanced sciences should have the storage room to the front. The other room, which will be used for the less advanced science and not demand as frequent use of science apparatus, will thus have the storage room in the rear.

It is suggested that the storage room be divided by a full partition so that chemicals may be segregated from the science materials. By this arrangement fumes from the chemicals will not corrode or otherwise affect the apparatus. At the same time the room may serve in smaller schools as a dark room. When two classroom laboratories compose the science layout, the door to the chemical storage room should open into the front of the room used for advanced science instruction. This door, as well as the door or doors from the other part of the storage room, should be a split door, or a door with a window, to facilitate the dispensing of supplies to pupils.

The construction of the shelving and drawers in these rooms should be carefully planned. The sides of the rooms provide the main space for storage. The shelves and drawers should be constructed for specific types of materials. The height between the shelves, the width of the shelves, and the depth and size of the drawers should be made to conform to the height and size of the objects to be stored. Wide shelves necessitate storing materials back of others, thus making it difficult to locate material and to take it from the shelves. Open shelving is much preferred to shelves encased by doors. If necessary, the shelves may be built to the top of the room. A stepladder can be used to secure the material beyond the normal reach of the teacher. Many schools are buying several years' supplies at a time in order to effect a saving by quantity purchases. The top shelves provide excellent space for storing this excess material.

A counter, which in reality is a broad shelf approximately 20 inches wide, forms an essential part of the storage room equipment. It should be placed only on one side of the storage room, at a height of approximately 36 inches. A portion of this 20 inch shelf could be covered with asbestos board one-eighth of an inch thick. It is applied the same as linoleum, and can readily be replaced when marred or worn out. The space underneath the counter is divided into drawer and cabinet compartments. The opposite side of the room is utilized only for shelf space.

A window shelf or work bench should be placed in the space in front of the window in the storage room. It is essential that such provision be included for teachers' use in developing new experiments, in reviewing work later to be demonstrated before the class, or in serving as a suitable location for continuing experiments which require a longer period of time for completion. Some of the space beneath this may be utilized for the construction of filing cases or drawers in which are placed the inventory cards, the cards used for the requisition of new supplies, or other filing cards that are required from time to time during the school term.

The suggestions for equipping a modern science room given in this article are the reactions of many experienced people. While it may be that some science teachers will not be in full accord with the details, it is hoped that the persons responsible for the planning of new science rooms, or the modification of existing rooms, will find guidance and assistance. This type of equipment, used by a teacher who views science as functioning in the lives of boys and girls, will guarantee a science room that will be more than four walls. It will become a general work shop where youth will be better able to find expression for their interests, and thus live vitally within the school.

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Making a Microscope

Continued from Page Seventy-eight

After finishing, the parts are assembled and the instrument is ready for inspection.

INSPECTION

The inspection of a microscope covers the following points:

1. The inspection of the separate parts includes inspection of the mechanical movements, the precision of the fit and the alignment, so that the instrument is accurately aligned in any position.

Optical parts are individually tested for optical uniformity, for concentricity, and performance. It is in this operation that the objectives are adjusted so that they will be parfocal (all objectives on the same revolving nosepiece will be in focus at the same setting of the coarse adjustment). Careful inspection of objectives, eyepieces, and substage condensers is carried out here.

2. After the microscope and parts have been entirely assembled, a careful check by two different men assures a standard instrument. The inspectors test the tension of the inclination joint, and after placing a target on the stage, test the alignment of the mechanical movement, both body tube and substage condenser. The standards to which these men work are infinitesimally small. The mechanical movements of the microscope must be accurate to within a few microns. They also

inspect the objectives by means of an Abbé test plate for optical performance.

CARE OF THE MICROSCOPE

Microscopes which are to be used in precise laboratory work where life and death are balanced must be as perfect as human ingenuity can make them. They should remain in good condition for many years.

The microscope stand should be kept free from dust. When it is not in use the microscope should be placed in its case under a bell jar or covered with a close-mesh cloth such as cotton, flannel, or velvet. If dust settles on the instrument, it should be removed with a camel's-hair brush. The microscope is then wiped clean with chamois skin or cloth.

Remove Canada balsam or cedar oil which may adhere to any part of the stand by using a cloth moistened with xylol; then wipe it dry with chamois. Do not use alcohol on brass parts, since they are lacquered and the lacquer would be removed. Black parts or chromium parts are alcohol proof.

When the instrument is handled, it should be grasped by the pillar or arm and should be set down carefully to avoid sudden jars. If your microscope contains a draw-tube, move it by imparting a spiral motion. If it is necessary to use a screwdriver on your microscope, grind its two large surfaces so that they are parallel and not wedge-shaped. It should exactly fit in the slot of the screw-head. If the inclination joint should become loose so as to prevent the arm being set at any angle of inclination desired, it should be tightened by drawing up the nut at one or the other side.

Special care should be given to keep the coarse adjustment free from dust, as its effect is serious. It should be cleaned with xylol and lubricated with paraffin oil. The teeth of the coarse adjustment should not be oiled but should be cleaned periodically with a toothbrush. If the fine adjustment ceases to work satisfactorily, the instrument had better be returned to the maker, as it involves the most delicate work and few people are conversant with its construction.

Every outfit should be provided with a camel's hair brush and a well-washed piece of linen. On account of its fine texture, chamois skin is desirable for cleaning lenses, but only after it has been repeatedly washed. No dust should be permitted to settle upon the lens, nor should the fingers touch any of the surfaces.

At regular periods, unscrew the eye-lens and field-lens and clean the inner surfaces. The lens systems should never be separated, even if they can be unscrewed, as dust may enter. Avoid all violent contact of the front lens with the cover glass. Oil immersion objectives particularly require the best care. Clean an immersion objective immediately after it has been used, by removing the fluid with lens paper. If necessary, the lens paper may be moistened with xylol.

Visible defects in the field are always traceable to materials on the eyepiece. Clean the surfaces of the eyepiece by breathing upon them and giving a revolving motion with the hand. Wipe well with washed linen.

A good microscope should give a lifetime of good service if these precautions are followed.

Semi-Micro Methods

Continued from Page Seventy-one

REAGENT BOTTLES: Of 30 cc. capacity equipped with ground-in glass pipettes or with rubber stoppers. Concentrated acids and bases are kept in these.

REAGENT BLOCKS: The vials with solid and liquid reagents are kept in these blocks. Their size is dependent upon the number of reagents required. In a college course the size of the block for the liquid and solid reagents is 9 inches by 9¾ inches; it contains 16 holes for liquid reagents and 120 holes for solids and test tubes.

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A brief description of some of the principal methods will give a clearer insight into the technique of this method.

PRECIPITATION: This process is carried out by combining a drop of precipitant and one of the solution to be precipitated on a glass microscope slide, on a spot plate, or in a test tube.

FILTRATION: (a) This process may be carried out on a glass slide by using a medicine dropper and a piece of cotton. The cotton is placed at the edge of the solution, and the opening of the dropper, with the bulb compressed, is pressed down on the cotton. The pressure on the bulb is slowly released and the cotton pushed through the solution and against the precipitate in such a way as to encircle it. The solution is thus filtered through the cotton and the precipitate is left on the slide.

(b) Filtrations are rapidly and effectively accomplished by centrifuging.

EVAPORATION: Liquids are evaporated by gently warming the drops of liquids on glass slides, on small watch glasses, or in crucibles which serve as evaporating dishes.

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Typical directions, as used by the class at Mount Mercy Academy and involving some of the apparatus and methods described above, are here given. These are taken at random from some of the experiments.

From the experiment on chlorine: "Place a very small pinch of potassium permanganate in the bottom of a test tube and add 5 drops of concentrated hydrochloric acid. Try a small pinch of manganese dioxide and 5 drops of hydrochloric acid." In the same experiment chlorine gas is generated from 0.5 gm. of potassium permanganate and 3 cc. of hydrochloric acid; the gas is collected in vials and is retained by stopping with corks.

Hydrogen is generated in a small test tube using a set-up such as used for the preparation of oxygen from potassium chlorate and manganese dioxide. A few pieces of mossy zinc and 5 cc. of hydrochloric acid are used and the gas is collected in vials by displacement of water. The gas in the vials gives excellent tests for combustion and diffusion, and there is no danger of an explosion.

An experiment on decantation, filtration, evaporation, precipitation, and distillation is made on the mixture: "a pinch of fine sand to which is added 10 drops of water, 5 drops of potassium chromate solution, and 2 drops of ammonium hydroxide." During the course of the experiment a drop of lead nitrate is added to a drop of the solution on a glass slide to illustrate precipitation and filtration.

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From these directions and descriptions it will be seen that the semi-micro methods are comparatively simple. It has been argued against the method that inasmuch as large equipment is generally used in subsequent courses and in commercial laboratories the student will not have the proper technique to cope with these larger scale methods. It has been found, however, that with those students who continue in chemistry there is no inability to quickly acquire proficiency in the use of larger apparatus. Furthermore, because of their training in semi-micro methods, they have developed better powers of observation. As a further answer to the objection that advanced courses will not make use of this technique, it might be pointed out that certain colleges are adopting these methods for inorganic and analytical chemistry, and that quantitative microanalysis of organic compounds has reached a highly refined stage.

The authors of this paper will welcome comments or inquiries. They will gladly extend any help which they can to those desiring added information on semi-micro methods.

In Hoc Signo Vinces

Continued from Page Sixty-seven

and just people interested in the unusual. During these visits the work for the flight continued, of course. Electricians charged the batteries, mechanics drilled holes for fastening the instruments, and so on.

Among our distinguished visitors one day while the painters were painting all our instruments in white, was a priest who came with half a dozen seminary students. I have forgotten his name, but I remember that he was a delightful man and we talked about many things. I suggested that, as a souvenir of his visit, he write something on the big cross. As he hesitated, I said an appropriate dedication would be: "In hoc signo vinces." He was kind enough to accept my idea and made the inscription in ink with well-shaped large letters.

Half an hour later I discovered to my sorrow that a painter had painted the cross all over. I had neglected to warn him not to paint over the dedication. The priest was still in the hangar and I told him, apologetically:

"I'm sorry, Father, the painters have painted the cross and have painted all over your inscription."

"Never mind," he said, with composure, "It is still there."

He was right.

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